農産物価格とバイオ燃料

Agricultural Commodity Prices and Biofuels

矢　野　佑　樹
Yuki YANO

概要

米国におけるエタノール産業の急速な発展は，農産物とエネルギー市場の連関を劇的に変化させてきた。世界的な食料安全保障に対する関心の高まりから，米国バイオ燃料政策と予測不可能な外的ショックの農産物価格に対する影響を分析することは重要である。本稿では，米国内エタノール利用の限界を考慮に入れてそれらの分析を行った。その結果，燃料混合業者に対する物品税控除額の増加は農産物価格を上昇させるが，もし米国内のエタノール利用が飽和状態にある場合にエタノールが輸出できなければ，価格への影響は小さいことが判明した。加えて，トウモロコシ・エタノールによって達成可能な使用義務量の増加は，農産物価格の上昇を引き起こすことが明らかになった。

キーワード：エタノール、農産物価格、物品税控除、再生可能燃料使用義務、食料安全保障

Abstract

The rapid development of the U.S. ethanol industry has dramatically altered the linkage between agricultural and energy markets. Given concerns about global food security, it is important to analyze how U.S. biofuel policies and unpredictable shocks affect corn and other agricultural commodity prices. Considering the potential impacts of the blending limitation on the ethanol market, this study examines the implications of the current U.S. biofuel policies for commodity prices. The impact of external shocks on these prices is also discussed. The results show that an increase in the tax credit, subsidy for fuel blenders, basically results in higher commodity prices. When the domestic ethanol market becomes saturated, the tax credit could increase commodity prices if U.S. ethanol can be exported. Without exports it could have a small impact on prices. Additionally, as the mandated amount of renewable fuel use that corn-ethanol will count towards increases, commodity prices will be increased.

Keywords: Ethanol, agricultural commodity prices, tax credit, mandates, food security

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1. Introduction

The rapid growth of the ethanol industry in the United States, based primarily on corn as a feedstock, has dramatically altered the linkage between agricultural and energy markets. Proponents of biofuels promote its use on several grounds, such as reducing greenhouse gas emissions, improving energy security, increasing farm incomes, and job creation. The major U.S. policy instruments for bioethanol have been tax credits (subsidies) for mixing the product with gasoline, an import tariff on fuel ethanol, and the Renewable Fuel Standard (RFS) which requires minimum usage levels for renewable fuels (biofuel use mandates). In addition to these policy instruments, there has been an increase in demand for ethanol due to higher petroleum-based transportation fuel prices and a ban on the use of MTBE (Methyl Tertiary-Butyl Ether) as an oxygenate to reduce air pollution.

A sharp increase in ethanol production has led to higher use of corn in ethanol production, resulting in higher prices of corn. Prices of other major agricultural commodities, such as wheat and soybean, have also moved together in the same direction. Record high prices for major agricultural commodities and feed grains occurred in 2008 and promotion of ethanol production and consumption has often been cited as the cause of the recent spike in food prices (Muhammad and Kebede, 2009). Although other factors, such as an increase in food demand in developing countries, supply shocks due to bad weather, and the depreciation of the U.S. dollar, have contributed to these higher commodity prices, a rapid increase in corn usage in energy production has apparently played an important role.

Increased food prices could have a serious impact on people around the world. Given the role of the United States in the international agricultural commodity markets, it is important to analyze how U.S. biofuel policies and unpredictable shocks, such as corn supply shocks and oil price shocks, affect corn and other agricultural commodity prices. Although many studies have examined the impact of U.S. biofuel policies on the average corn price levels or trends, their impact on price volatility has received limited attention (Elobeid and Hart, 2007). McPhail and Babcock (2008) use a stochastic partial equilibrium model to investigate the effect of increased U.S. ethanol production on price risk for corn. Using output from a partially stochastic simulation Thompson *et al.* (2009a) examine how variations in corn yield and the petroleum price affect corn and ethanol prices, and ethanol use with or without a U.S. mandate. Hertel and Beckman (2010) investigate the impact of the RFS and blending limitations on the volatility of U.S. coarse grains prices, but the possibility of trade in ethanol is not considered.

This paper examines the implications of the current U.S. biofuel policies on corn and other agricultural commodity prices. We also discuss the impact of external shocks on these prices. To do this, we consider the potential impacts of the blending limitation on the ethanol market. In the United States, an ethanol blend ratio with gasoline is restricted for most vehicles up to 10 or 15 percent. Recently the U.S. ethanol industry is nearing or has already reached the maximum feasible amount of domestic ethanol consumption due to this blending limitation and the lack of infrastructure (Taheripour and Tyner, 2008; Wisner, 2010).

The remainder of the paper is organized as follows. In the following section we define the linkage between corn and energy markets and analyze the impact of ethanol production on the price of corn. The relationship between corn and other agricultural commodities such as soybeans, wheat, and beef is also discussed. In addition, the impacts of corn supply and gasoline price shocks on corn prices are investigated. In section 3, we examine the impact of subsidies for ethanol blending on the price of corn and its variability. The impact of the Renewable Fuel Standard on the commodity prices is analyzed in section 4. The final section summarizes our conclusions and their implications.

2. Ethanol Production and Agricultural Commodity Prices

To investigate the impact of policy instruments promoting ethanol production and use on corn and energy markets in the United States, we first need to define the linkage between these. Then we discuss how variability can be introduced into the markets in order to examine how external shocks affect commodity prices. We begin with the static model presented by de Gorter and Just (2008) employing nonlinear supply and demand curves. The impact of biofuel policies on prices is investigated in the following section.

Consider a competitive market with an aggregate supply curve for corn S_C and an aggregate non-ethanol demand for corn D_{NE} (including domestic food and livestock feed demand, and foreign demand for corn). Any market returns to ethanol by-products (e.g., distillers' grains) are assumed to be reflected in the demand curve. Assuming constant returns to scale, the supply of ethanol S_E is derived from the horizontal difference (excess supply) between S_C and D_{NE}. Therefore, their intersection represents the equilibrium corn price without ethanol production, p_{NE} , and this defines the intercept of the ethanol supply curve (see fig. 2-1).

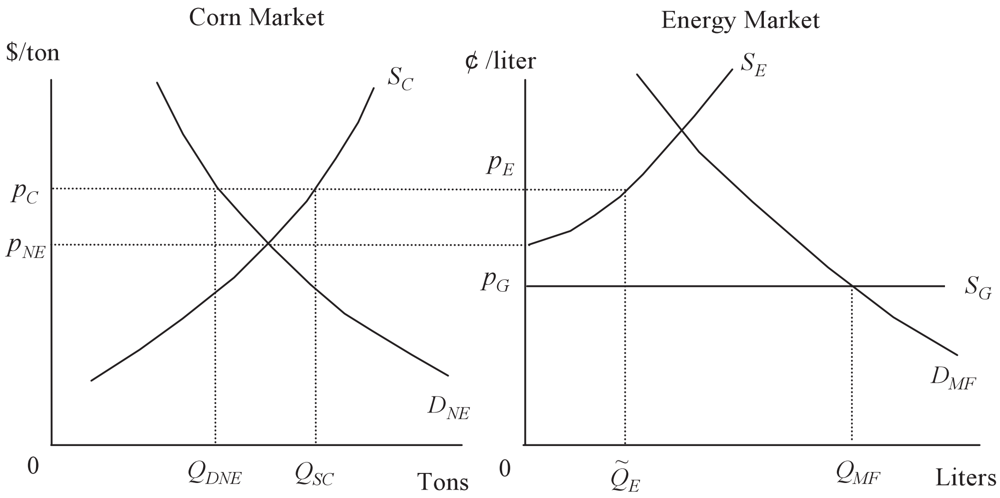

Fig. 2-1 The linkage between corn and energy markets

Following de Gorter and Just we assume that oil price is exogenous (so is gasoline price) and perfect substitutability between ethanol and gasoline. Suppose the energy market is also competitive. Let S_G denote the supply curve for gasoline (perfectly elastic) and p_G the gasoline price, which is the sum of the oil price and an excise fuel tax. The demand for mixed fuel (blended fuel) is denoted by D_{MF}. Total fuel consumption Q_{MF} is determined at the intersection of S_G and D_{MF} (if there is no ethanol production, gasoline accounts for all liquid fuel usage). The intercept of the ethanol supply curve is assumed to be higher than the price of oil (the gasoline price minus the tax). Thus, if there are no biofuel policy measures the quantity of ethanol produced and consumed is zero.

Suppose the quantity of ethanol used is $\tilde{Q}_E$, the market (supply) price for ethanol, p_E , is determined by the supply curve for ethanol. The corn price is determined at p_C which is directly linked to p_E. Since any market returns to ethanol by-products are reflected in the demand curve, $Q_{SC}-Q_{DNE}$ represents the net removal of corn for ethanol production. The relationship between the corn price and the ethanol price is:

$$p_C = \left(\frac{k}{1-\tau}\right) p_E - c. \tag{1}$$

where k represents gallons of ethanol produced from one bushel of corn, τ is the proportion of the value of corn returned to the market in the form of by-products, and c is processing costs. According to de Gorter and Just (2008, 2009), the estimate of $k/(1-\tau)$ for corn in the United States is 4.06, which means that the corn price is very sensitive to a change in the price of ethanol. Given the corn supply and demand curves (in the absence of ethanol production), as the quantity of ethanol supplied increases, the price of corn becomes higher.

What is the relationship between corn and other agricultural commodities (e.g., wheat, soybean, and poultry)? On the supply side, since corn competes with other agricultural commodities for land, an increase in the demand for corn (i.e., the price of corn rises) results in reduced supplies of other commodities (less acreage is allocated to them). Consequently, higher commodity prices occur. On the demand side, with increased corn demand, the demand for competing inputs in food and feed manufacturing is increased, thereby increasing their prices. Also, since corn is the primary food source for livestock, as the price of corn rises, livestock production costs are increased. Thus, livestock product prices (meat, dairy products, and eggs prices) should increase, holding other factors unchanged.

Commodity prices inevitably vary through time as a result of systematic changes in supply and demand, but volatility in ethanol use and commodity prices is created by “unpredictable” changes in external factors. Arguably, it is such unpredictable changes that are most disruptive because of the unforeseen costs that they can impose on producers and consumers. In terms of the U.S. corn-ethanol market volatility in the following factors are the most important: a) the gasoline price (oil price); b) domestic corn supply; and c) the world ethanol price.

Historically, the correlation between energy and corn prices has been low (Muhammad and Kebede, 2009). The rapid development of the ethanol industry has dramatically altered that linkage. Since fuel ethanol and gasoline are assumed to be perfect substitute, fluctuations in the price of gasoline (petroleum) will have a large impact on the U.S. domestic and foreign demand for ethanol if the use of ethanol is unconstrained. In this case, gasoline (petroleum) and ethanol prices move together. If the price of gasoline rises, the demand for gasoline is reduced, whereas the demand for ethanol is increased. Ethanol replaces gasoline until both prices are equal. An increase in the demand for corn from ethanol industry results in a higher corn price. Consequently, the price of corn varies with the price of gasoline (petroleum). Due to the indirect effect of corn prices on other agricultural commodity prices discussed above, their prices will follow the same pattern. In addition to the indirect effect, there is also a direct effect of energy prices on other commodity and food prices. Higher energy costs increase transportation, processing, and retail costs, resulting in higher retail prices of most food products.

Fluctuations in corn supply (e.g., due to bad weather) affect the price of corn and hence the costs of ethanol production. But if ethanol output is flexible, variations in the volume of production can absorb shocks from the corn market because the demand for corn ethanol is likely to be very elastic due to perfect substitution between ethanol and gasoline. In this case, the impact of corn supply on ethanol and corn prices is instantaneous. Changes in supply will cause the quantity of ethanol production and corn use to change sharply, whereas the changes in the price of ethanol and corn will be small. In contrast, if the demand for corn-based ethanol is very inelastic, fluctuations in corn supply will cause ethanol and corn prices to vary sharply. Since ethanol volume cannot be adjusted, the brunt of adjustment to fluctuations in corn supply would be borne by prices.

Finally, world ethanol prices could affect the price of corn. Fluctuations in world ethanol prices have no impact on the domestic market due to the protection afforded by the import tariff, unless world prices become sufficiently high so that U.S. corn-based ethanol producers can sell their products competitively to foreign blenders or consumers. Recent world ethanol prices, which are largely determined by the availability of sugarcane-based ethanol supplies from Brazil, have been relatively high due to high sugar prices. Fluctuations in world ethanol prices that result in exports of U.S. ethanol affect the total demand for corn-based ethanol and the price of corn.

3. The Impact of Subsidies on Prices

On the basis of the model presented in the previous section we are now able to examine the impact of the tax credit on commodity prices. Fuel blenders can claim $0.45 per gallon federal tax credit (subsidy) by blending ethanol with gasoline. Thus, the tax credit reduces the marginal cost of ethanol production (blended fuel production).

We assume that a given per gallon excise tax, t, is imposed on motor fuel. A tax credit per gallon, s, is provided for ethanol. Hence, the inverse supply curve, inclusive of the tax, shifts downwards by the amount s and biofuel producers bid up the price of ethanol (demand price) to the gasoline price in order to maximize their benefit (de Gorter and Just, 2008). The quantity of ethanol used Q_E is determined where the inverse supply curve, including the tax credit, S'_E , intersects the gasoline price p_G (including the excise tax, i.e., $p_G = p_O + t$). The market price of ethanol (supply price) p_E is determined by the initial ethanol supply curve and equals the price of oil (without tax) plus the tax credit. The market price for mixed fuels is equal to the gasoline price. Total fuel consumption, Q_{MF} , does not change and gasoline is replaced by ethanol by the amount Q_E . In this case only blenders gain from the subsidy. As the level of the tax credit increases, ethanol use increases, gasoline use decreases, and the price of corn rises, if there is no constraint on the domestic use of ethanol. The market equilibrium with the tax credit is illustrated in fig. 3-1.

If the U.S. ethanol industry reaches the blend wall, which refers to a maximum feasible amount of ethanol that can be consumed domestically due to technical limitations in the current vehicle fleet, the tax credit could encourage ethanol refineries and blenders to produce blended fuel for export. Hence, with the blend wall, the tax credit could increase the likelihood that the petroleum price and world ethanol price will affect the supply of corn-based ethanol and the corn price.

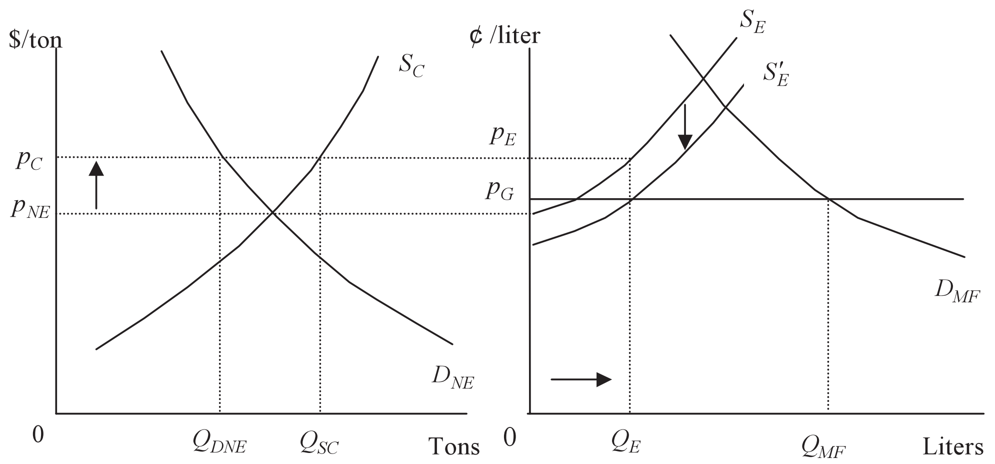

Fig. 3-1 The impact of tax credit on the markets

Let α represent the maximum ethanol share in all fuel sold due to the blending limitation. Then, the domestic ethanol use is determined at the point where S'_E , intersects αQ_{MF} (the domestic demand for ethanol) (fig. 3-2). If we assume that the foreign demand for U.S. corn-based ethanol is perfectly elastic at the world ethanol price p_W , the quantity of ethanol supplied and the price of corn are determined at the point where S'_E intersects p_W . The amount of ethanol $Q_E - Q_{DE}$ is exported. If the world ethanol price rises, the price of corn is increased and thus other commodity prices are also increased. If the world ethanol price falls sufficiently so that ethanol is not exported, the domestic demand for ethanol becomes very inelastic if the industry hits the blend wall.

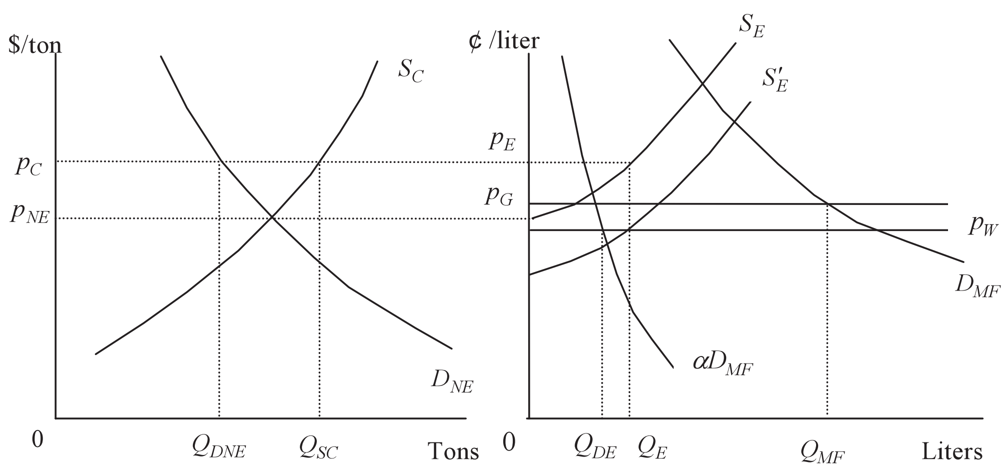

Fig. 3-2 The impact of world ethanol prices on the markets with the blend wall

When the ethanol industry hits the blend wall, if the tax credit is increased with exports, the corn and other agricultural commodity prices increase. Without exports, the tax credit simply reduces the price of mixed fuel and the price of corn is not affected significantly.

Because the minimum mandatory use of ethanol is approaching current blend-wall estimates of around 13 billion gallons (Renewable Fuels Association, 2010), the removal of the tax credit is likely to result in very inelastic demand for corn-based ethanol. Even if the tax credit is maintained, ethanol demand would be very inelastic if the world ethanol price is sufficiently low. In this case, variations in corn supply would have a large impact on corn and other commodity prices, whereas variations in oil price would have a small impact. If an increase in the tax credit can increase the likelihood of ethanol exports, the price of petroleum would be more likely to affect the commodity prices.

4. The Impact of the Renewable Fuels Standard on Prices

The Renewable Fuel Standard (RFS) under EISA of 2007 requires that "*transportation fuel sold or introduced into commerce in the United States contains at least the applicable volume of renewable fuel, advanced biofuel, cellulosic biofuel, and biomass-based diesel*" (EISA. H.R.6 Title XV, Subtitle A, Sec. 202). Note that the legislation does not establish a mandate for corn-based ethanol (termed conventional biofuel). Rather, as part of the overall mandate, the use of (advanced) renewable fuels other than ethanol derived from corn starch is mandated. Corn-based ethanol can be used to meet the difference between the overall mandate and the advanced biofuel mandate if there is no cheaper alternative. Nevertheless, it is expected that corn-based ethanol will have to be used to meet a large part of the RFS in the medium term future because other types of biofuels would not be economically viable beyond the volume required by the advanced biofuel mandate (Thompson *et al.*, 2009b) and imports are restricted by tariffs even if the world ethanol price becomes low. The mandated volume of use that corn-based ethanol will count towards will be increased annually until 2015 when it peaks at 15 billion gallons.

Suppose corn-based ethanol has to be used to meet the overall mandate less the advanced mandate. If the costs of ethanol production are high relative to the price of gasoline, the quantity of ethanol produced will be equal to the minimum mandated use Q_{ERFS} (fig. 4-1). The price of corn becomes higher than that in the absence of the RFS. In this case, as the mandated amount of use that corn-based ethanol will count towards increases, the demand for corn will be increased and the price of corn will rise, resulting in higher other commodity prices. The RFS does not have an impact on the corn price if the marginal benefit of ethanol production exceeds its marginal cost at the mandated amount.

If blenders are forced to meet the RFS on the production of blended fuel that exceeds the blend wall, and world ethanol prices are low, an amount equivalent to the difference between the mandate and the blend wall maximum will be exported to (dumped on) the international market.

As long as the mandate is binding where the quantity of ethanol supplied equals the mandated amount, the demand for corn-based ethanol will be very inelastic. As the mandated volume under the RFS increases annually, the likelihood that the mandate will be binding increases because the marginal cost of ethanol production at the required level increases, holding other things constant. In other words, the current RFS will increase the likelihood that the demand for ethanol will become very inelastic. Therefore, fluctuations in domestic corn supply would be more likely to have an impact on domestic ethanol and corn prices, whereas the fluctuations in petroleum and world ethanol prices would be less likely to affect these. Volatility in domestic ethanol and corn prices would likely increase if fluctuations in domestic corn supply are high relative to fluctuations in petroleum and world ethanol prices, and vice versa.

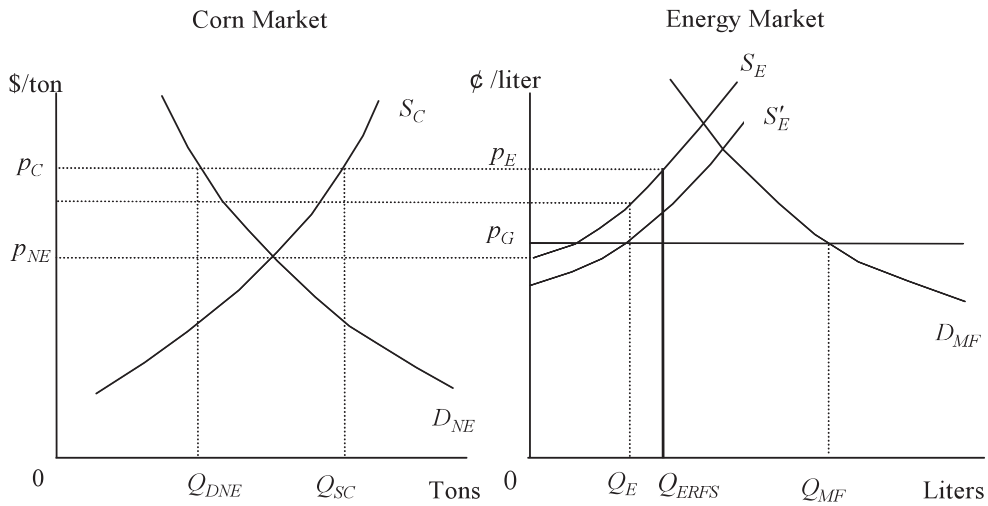

Fig. 4-1 The impact of the RFS on the markets

5. Conclusions

The rapid development of the U.S. biofuel industry has altered the linkage between agricultural and energy markets. A sharp increase in the use of corn in energy production has contributed to higher corn and other agricultural commodity prices. Given concerns about global food security and the role of the U.S. in the international agricultural markets, it is indispensable to examine the impact of current U.S. biofuel policies and unpredictable shocks such as corn supply and oil price shocks on commodity prices. Taking account of the potential impacts of the blend wall on the ethanol market, this paper examines the implications of the tax credit (subsidy) and the Renewable Fuel Standard (mandates) on corn and other agricultural commodity prices and their variability. The impacts of external shocks on these prices are also discussed.

The results indicate that as the level of the tax credit increases, basically commodity prices become higher. When the use of ethanol in the domestic market is limited, the tax credit could increase commodity prices if the world ethanol price is sufficiently high so that U.S. ethanol producers can export their products to foreign countries. In the absence of ethanol exports due to low world ethanol prices, the tax credit could have a small impact on prices. Unless the tax credit can increase the likelihood of ethanol exports, variations in corn supply would have a large impact on corn and other commodity prices, whereas variations in oil price would have a small impact because the demand for corn-based ethanol would be quite inelastic. With exports the price of petroleum would be more likely to affect the commodity prices.

In addition, if the costs of ethanol production are high relative to the price of gasoline, as the mandated amount of renewable fuel use that corn-ethanol will count towards increases, commodity prices will be increased. The RFS will not have an impact on prices if the marginal benefit of ethanol production exceeds its marginal cost at the mandated volume. As the mandated volume under the RFS increases annually, the likelihood that the mandate will be binding increases because the marginal cost of ethanol production at the mandated volume increases, holding other things unchanged. Since the likelihood that the demand for ethanol will become very inelastic is increased, fluctuations in domestic corn supply would be more likely to have an impact on corn and other commodity prices, whereas the fluctuations in petroleum and world ethanol prices would be less likely to affect these. Volatility in commodity prices would likely increase if fluctuations in domestic corn supply are high relative to fluctuations in petroleum and world ethanol prices, and vice versa.

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